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Evaluation of keros classification and fovea ethmoidalis asymmetry in patients with lamina papyracea dehiscence

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Abstract

To evaluate the relationship between the side, grade, and herniated content of lamina papyracea dehiscence (LPD) detected on paranasal sinus computed tomography (CT) and olfactory fossa depth (OFD), Keros classification, right-to-left OFD difference, and fovea ethmoidalis asymmetry. This retrospective study included 50 patients with LPD identified on paranasal sinus CT between January 2020 and June 2026 and 50 age- and sex-matched control subjects. The presence, side, and grade of LPD were recorded. OFD was measured bilaterally, and Keros classification was determined. Right-to-left OFD difference and fovea ethmoidalis asymmetry were also evaluated. In the LPD group, dehiscence was located on the right side in 46% of patients, on the left side in 52%, and bilaterally in 2%. No significant differences were observed between the LPD and control groups with respect to Keros classification or OFD. However, the LPD group demonstrated significantly greater right-to-left OFD difference classification ($p = 0.04$) and a higher prevalence of fovea ethmoidalis asymmetry ($p < 0.0001$) than the control group. Correlation analysis revealed moderate positive correlations between the right-to-left OFD difference and left OFD ($r = 0.547$, $p < 0.0001$), as well as left Keros type ($r = 0.401$, $p = 0.004$). In addition, a moderate negative correlation was observed between fovea ethmoidalis asymmetry and left Keros type ($r = -0.456$, $p = 0.001$). Although Keros classification and OFD did not differ between the LPD and control groups, a greater right-to-left OFD difference and a higher prevalence of fovea ethmoidalis asymmetry were observed in patients with LPD. These findings suggest that LPD is not merely an isolated defect of the medial orbital wall but may be associated with anterior skull base asymmetry. Reporting these anatomical parameters during preoperative CT evaluation may improve surgical planning and help reduce the risk of orbital and anterior skull base complications during functional endoscopic sinus surgery.

Keywords: Ethmoid bone; skull base; anatomic variation; paranasal sinuses; tomography, X-ray computed

Introduction

Detailed radiological evaluation of the paranasal sinuses and adjacent anterior skull base structures is critical to prevent complications before functional endoscopic sinus surgery (FESS). The lamina papyracea is the thinnest wall among the bony structures separating the ethmoid sinuses from the orbit, and due to this feature, it is the region most prone to the development of dehisence due to both traumatic and congenital or iatrogenic reasons [1]. The lamina papyracea dehiscence (LPD) is a congenital anatomical variation that is mostly asymptomatic and forms a direct neighborhood between the ethmoid sinus and the orbital contents (adipose tissue, rarely medial rectus muscle) [2,3]. Its incidence reported in the literature varies widely, from 0.76% to 10%, depending on the population studied and the imaging modality [2]. The clinical significance of LPD is twofold: first, it can be confused with ethmoid sinusitis or mass lesion if left unrecognized, leading to unnecessary examination/treatment; the second is that accidental injury to orbital adipose tissue or extraocular muscles during FESS predisposes to serious complications such as orbital hematoma, orbital emphysema, and extraocular

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muscle damage [3,4]. Therefore, systematic classification of the presence, side, defect size and content (fat or fat + muscle) of LPD in preoperative computed tomography (CT) examination is recommended for the safety of surgical planning [1,2]. Another critical region of the anterior skull base is the olfactory fossa (OF), which forms the lateral wall of the cribriform plate, and the lateral lamella surrounding it. The depth of OF is defined as the vertical distance between the ethmoid roof (fovea ethmoidalis) and the cribriform plate and is divided into three categories defined by Keros in 1962: Type I (1 – 3 mm), Type II (4 – 7 mm), and Type III (8 – 16 mm) [5,6]. As the depth of the OF increases, the lateral lamella lengthens and becomes thinner; this significantly increases the risk of skull base perforation, cerebrospinal fluid (CSF) leakage, and intracranial complications during surgery [6,7]. In studies conducted in different populations, it has been reported that Type II is the most common type, while Type III is relatively rare but the most surgically risky group [6]. Asymmetry between right and left OF depths is also emphasized in the literature as a separate risk factor. If the difference in depth between the two sides exceeds a certain threshold (usually 2-3 mm in studies), it means that on the deeper side, the lateral lamella becomes more fragile and more prone to injury; In addition, the surgeon's unawareness of this asymmetry may lead to an unexpected skull base defect in the area considered as the safe side [6,8]. Similarly, height asymmetry between right and left at the level of the fovea ethmoidalis (ethmoid roof) has been defined as a separate risk parameter; Some studies have suggested that the ethmoid roof of the right side tends to be lower than the left side, which may increase the risk of complications in right-sided surgeries, especially in right-handed surgeons [9]. It is emphasized that the Keros classification alone may be insufficient to predict the risk of skull base injury, so it would be more comprehensive to consider the depth of AF, asymmetry assessment and fovea ethmoidalis configuration together [7-9]. In the literature, LPD and olfactory fossa depth (OFD), Keros classification and foveal ethmoidalis asymmetry have generally been examined in independent studies, and the number of studies comparing these two anatomical risk regions (medial orbital wall and anterior skull base) together in the same patient series is limited [1,6,10]. In the light of this information, we aimed to evaluate the relationship between the side, defect size and content characteristics of LPD detected on paranasal sinus CT and the accompanying OFD, Keros type, right-left OF depth difference and foveal ethmoidalis asymmetry. We think that such a co-evaluation may contribute to surgical safety by drawing attention to the possibility of the coexistence of two different high-risk sites in pre-FESS surgery planning.

Material and Methods

Study Population

This study was approved by the Pamukkale University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (Decision No.: E-60116787-020-906559; Date: 21.07.2026).

Paranasal sinus CT examinations of patients with LPD identified in the radiology archive of Pamukkale University Faculty of Medicine Hospital between January 2020 and June 2026 were retrospectively reviewed. Patients younger than 18 years of age; those with a history of craniofacial trauma, sinonasal or skull base surgery, congenital craniofacial anomalies, sinonasal polyps or masses, malignancy, invasive fungal sinusitis, or any other pathology that could secondarily compromise the integrity of the lamina papyracea or skull base; and patients with motion artifacts severe enough to preclude reliable measurements were excluded.

A total of 50 patients aged 18 – 80 years who met the inclusion criteria and had undergone imaging using a multidetector CT scanner (Ingenuity 128, Philips Healthcare, The Netherlands) were included in the study. In addition, 50 subjects who underwent paranasal sinus CT for the preliminary diagnosis of nasal septal deviation and were matched to the study group with respect to age, sex, and sample size were included as the control group.

Paranasal sinus CT examinations of 50 patients with LPD (36 men and 14 women; age range, 18 – 76 years; mean age, 45.40 ± 16.54 years) and 50 control subjects (36 men and 14 women; age range, 18 – 77 years; mean age, 45.22 ± 16.54 years) were retrospectively analyzed.

Paranasal Sinus CT

All paranasal sinus CT examinations were performed using a 128-detector multidetector CT scanner (Ingenuity 128, Philips Healthcare, The Netherlands). Imaging parameters were as follows: tube voltage, 120 kV; tube current, 120 mAs; slice thickness, 2 mm; and matrix size, 512 × 512. All examinations were performed without intravenous contrast administration.

CT images were evaluated on a dedicated workstation using axial, coronal, and sagittal reformatted images. Both bone-window images (window width, 2000 HU; window level, 500 HU) and soft-tissue-window images (window width, 350 HU; window level, 50 HU) were reviewed.

Image Analysis

Paranasal sinus CT images of all patients in both the study and control groups were evaluated on axial, sagittal, and coronal reformatted images using a dedicated radiology workstation.

The presence, side (right, left, or bilateral), content and grade of LPD were recorded (Figure 1). Dehiscence was graded according to the ratio of the dehiscence length to the total length of the lamina papyracea. A ratio of < 1/3 was classified as Grade 1, a ratio between 1/3 and 2/3 as Grade 2, and a ratio > 2/3 as Grade 3 (Figure 2).

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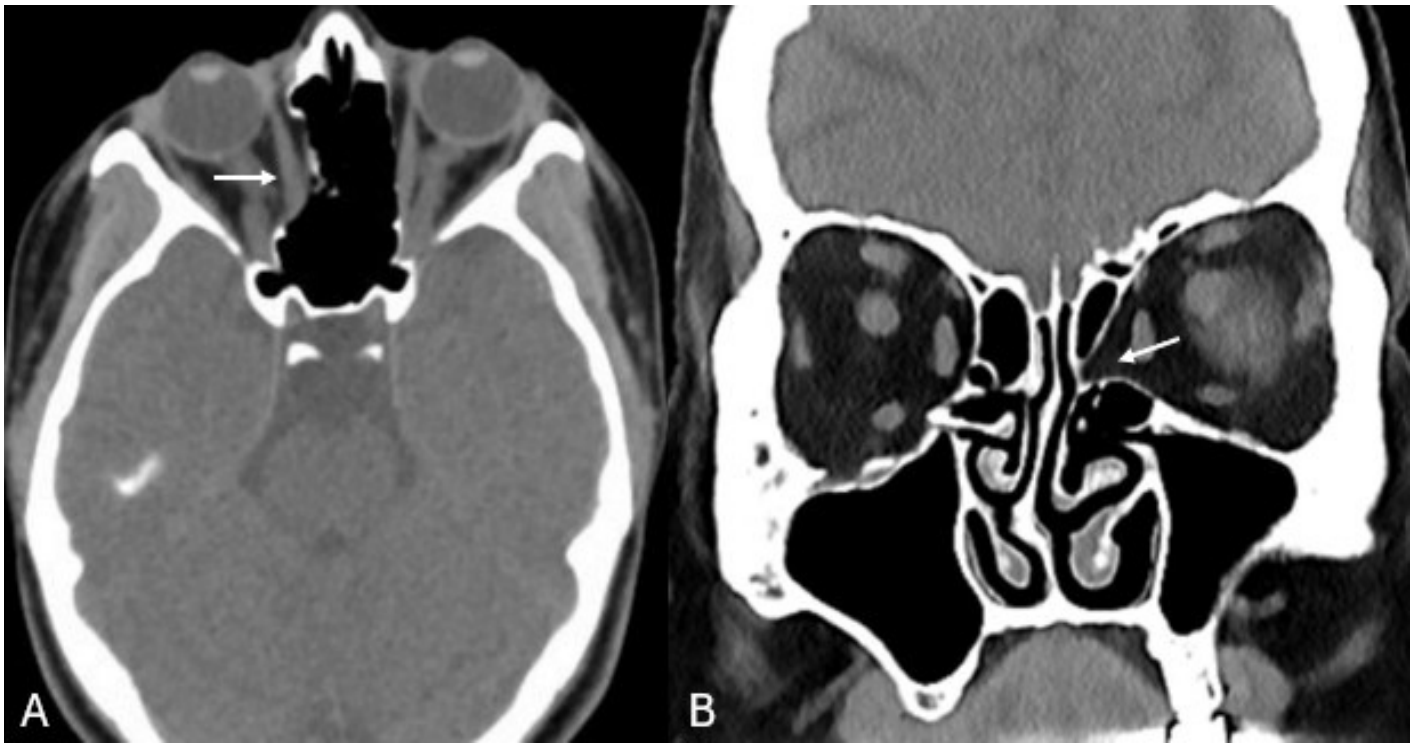


Figure 1. Axial paranasal sinus CT image demonstrating right LPD containing orbital fat and the medial rectus muscle (arrow) (**A**), and coronal paranasal sinus CT image demonstrating left LPD containing orbital fat (arrow) (**B**). Abbreviations: CT, computed tomography; LPD, lamina papyracea dehiscence.



Figure 2. Axial paranasal sinus CT image demonstrating Grade 3 dehiscence of the left lamina papyracea (arrow). Abbreviation: CT, computed tomography.

For each side, the OFD, defined as the vertical distance between the cribriform plate and the fovea ethmoidalis, was measured and classified according to the Keros classification as Type I, Type II, or Type III (Figure 3). The interside difference in OFD was categorized as Type A (< 1 mm), Type B (1 – 2 mm), or Type C (≥ 2 mm). In addition, the presence of fovea ethmoidalis asymmetry was evaluated (Figure 4).

All image evaluations and radiological measurements were performed by a head and neck radiologist with 22 years of experience.

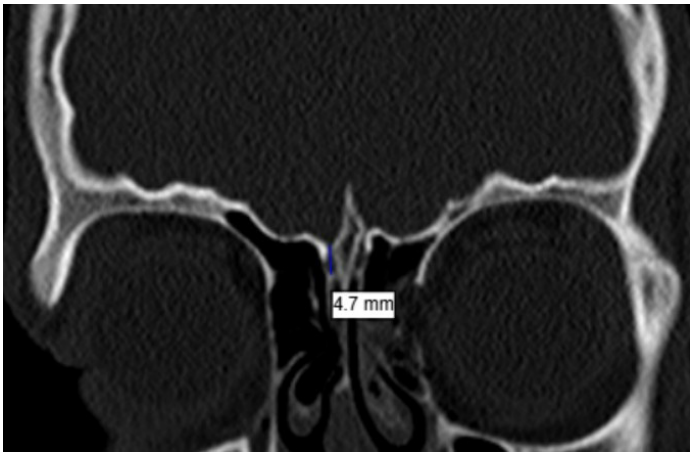


Figure 3. Coronal paranasal sinus CT image demonstrating the depth of the right OF (Keros Type II). Abbreviation: CT, computed tomography.

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Figure 4. Coronal paranasal sinus CT image demonstrating right fovea ethmoidalis asymmetry. Abbreviation: CT, computed tomography.

Statistical Analysis

Data analysis was performed using SPSS software (version 27.0 for Windows; IBM Corp., Armonk, NY). Descriptive statistics were presented as mean ± standard deviation for continuous variables and as frequencies and percentages for categorical variables. Independent-samples t-tests were used to compare continuous variables. Pearson correlation analysis was used to evaluate the strength and direction of linear relationships between continuous variables. Correlation coefficients (r) and corresponding two-tailed p-values were calculated. A p-value <0.05 was considered statistically significant.

Results

There was no statistically significant difference in the demographic characteristics between the 50 patients with LPD and the 50 control subjects included in the study. In both groups, 36 patients (61.9%) were male and 14 (38.1%) were female. The age ranged from 18 to 76 years (mean, 45.40 ± 16.54 years) in the LPD group and from 18 to 77 years (mean, 45.22 ± 16.54 years) in the control group, with no significant difference between the groups (t = 0.054, p = 0.991).

In the LPD group, dehiscence was located on the right side in 23 patients (46%), on the left side in 26 patients (52%), and bilaterally in 1 patient (2%). Among the right-sided LPDs, 14 (28%) were classified as Grade 1, 6 (12%) as Grade 2, and 4 (8%) as Grade 3. Among the left-sided LPDs, 9 (18%) were classified as Grade 1, 12 (24%) as Grade 2, and 6 (12%) as Grade 3. The herniated content associated with LPD consisted of orbital fat in 20 patients (40%) and orbital fat with medial rectus muscle in 4 patients (8%) on the right side, and orbital fat in 21 patients (42%) and orbital fat with medial rectus muscle in 6 patients (12%) on the left side.

No statistically significant differences were observed between the LPD and control groups with respect to Keros classification or OFD on either side. Comparison of right and left Keros classifications between the LPD and control groups. is presented in Table 1.

Table 1. Comparison of right and left Keros classifications between the LPD and control groups.

Keros clasification	Study group (n, %)	Control group (n, %)	p value
Right Keros clasification			0.840
Type 1	11 (22)	10 (20)	
Type 2	33 (66)	32 (64)	
Type 3	6 (12)	8 (16)	
Left Keros clasification			0.740
Type 1	12 (24)	14 (28)	
Type 2	26 (52)	27 (54)	
Type 3	12 (24)	9 (18)	

Abbreviations: LPD, lamina papyracea dehiscence.

A statistically significant difference was observed between the LPD and control groups regarding the right-to-left OFD difference classification (p = 0.04). Comparison of right-to-left OFD difference classifications between the LPD and control groups is presented in Table 2.

Table 2. Comparison of right-to-left OFD difference classifications between the LPD and control groups

Right-to-left OFD difference classification	Study group (n, %)	Control group (n, %)	p value
Type A	17 (34)	33 (66)	
Type B	17 (34)	6 (12)	0.004
Type C	16 (32)	11 (22)	

Abbreviations: LPD, lamina papyracea dehiscence; OFD, olfactory fossa depth.

Correlation analysis performed in the LPD group demonstrated a moderate positive correlation between the right-to-left OFD difference and left OFD (r = 0.547, p < 0.0001), as well as between the right-to-left OFD difference and the left Keros classification (r = 0.401, p = 0.004).

A statistically significant difference was observed between the LPD and control groups in terms of fovea ethmoidalis asymmetry (p < 0.0001). Comparison of fovea ethmoidalis asymmetry between the LPD and control groups is presented in Table 3.

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Table 3. Comparison of fovea ethmoidalis asymmetry between the LPD and control groups

Fovea ethmoidalis asymmetry	Study group (n, %)	Control group (n, %)	p value
Asymmetrical on the right	11 (22)	1 (2)	
Asymmetrical on the left	8 (16)	2 (4)	< 0.0001*
Symmetrical	31 (62)	47 (94)	

Abbreviations: LPD, lamina papyracea dehiscence.

Correlation analysis in the LPD group demonstrated a moderate negative correlation between fovea ethmoidalis asymmetry and the left Keros classification ($r = -0.456$, $p = 0.001$). In addition, a strong positive correlation was observed between the right and left Keros classifications ($r = 0.704$, $p < 0.0001$). Correlation analysis of Keros classification and fovea ethmoidalis asymmetry in the study group is presented in Table 4.

Table 4. Correlation analysis of Keros classification and fovea ethmoidalis asymmetry in the study group

Variables		Right Keros	Right-to-left OFD difference	Fovea ethmoidalis asymmetry
Left Keros	**Pearson r**	**.704****	**.401****	**-.456****
	p	**.000**	**.004**	**.001**
Right Keros	**Pearson r**		.267	-.263
	p		.061	.065

Abbreviations: OFD, olfactory fossa depth.

Discussion

In this study, patients with LPD identified on paranasal sinus CT were compared with a control group in terms of Keros classification, OFD, right-to-left OFD difference, and fovea ethmoidalis asymmetry. Patients with LPD exhibited significant differences in several skull base morphometric parameters compared with the control group. Our findings are largely consistent with the current literature regarding both the imaging characteristics of LPD and the surgical significance of anterior skull base asymmetry.

The lamina papyracea is a thin bony lamella that forms the medial orbital wall and separates the orbit from the ethmoid sinus. Congenital or acquired loss of bony continuity of the lamina papyracea (dehiscence) may result in herniation of orbital fat and, occasionally, the medial rectus muscle into the ethmoid air cells [1,3]. The clinical significance of LPD lies primarily in two aspects: preventing misinterpretation of this finding as an orbital fracture, mass, or infection in patients without a history of trauma, and informing the surgeon of the integrity of the medial orbital wall before FESS, thereby reducing the risk of intraoperative orbital penetration, extraocular muscle injury, orbital hematoma, and orbital infection [1,3,11,12]. In the landmark study published by Moulin et al. in 1994, which was the first to systematically describe LPD, CT scans of 783 patients were evaluated, and incidental LPD was identified in 6 patients (0.8%). The authors reported that the dehiscence was consistently confined posteriorly to the basal lamella, whereas its anterior extent was variable [3]. Since this pioneering study, the reported prevalence of LPD has ranged from 0.8% to 2% across different populations. For example, Deniz and Tekinhatun reported an LPD prevalence of 2% in a series of 1,000 patients, with 70% of cases classified as grade 1, 20% as grade 2, and 10% as grade 3. They also found that 70% of dehiscences were located on the right side and 30% on the left [1]. In the present study, grade 1 LPD was the most common subtype on the right side (28%), whereas grade 2 LPD predominated on the left side (24%). These findings suggest that the severity of dehiscence may differ between the two sides and that evaluating only one side may not accurately reflect the overall anatomical pattern. In contrast to the findings reported by Deniz and Tekinhatun, the left side was slightly more frequently involved than the right in our study (52%). Because LPD is uncommon, the side distributions reported in individual series are derived from small numbers of cases and are therefore susceptible to random variation. Taken together, these data do not support a consistent side predilection for LPD; consequently, the integrity of both medial orbital walls should be routinely evaluated on preoperative CT rather than assuming predominantly right-sided involvement [1]. Furthermore, Deniz and Tekinhatun reported that the herniated contents consisted of orbital fat in 83.3% of cases and the medial rectus muscle in 16.7%. Similarly, in our study, the herniated contents comprised orbital fat in 80.4% of cases and the medial rectus muscle in 19.6%, demonstrating a distribution comparable to that reported in the literature [1]. Notably, more than half of the dehiscent sides in our series (28/51, 54.9%) were grade 2 or 3, compared with 30% in the series reported by Deniz and Tekinhatun [1]. This difference is probably related to the fact that our study population consisted of patients with LPD identified from a radiology archive rather than a consecutive screening cohort, and it should therefore not be interpreted as a true difference in prevalence. From a clinical standpoint, however, it indicates that in a considerable proportion of patients with LPD the bony defect extends over a substantial length of the medial orbital wall, and that in approximately one in five dehiscent sides the medial rectus muscle lies directly within the ethmoid labyrinth, where it is exposed to injury during uncinectomy and ethmoidectomy [4,11].

In our study, no significant differences were observed between the LPD and control groups with respect to Keros classification or OFD. These findings suggest that LPD is not directly associated with OFD but rather reflects a localized anatomical weakness of the lamina papyracea, which forms the medial orbital wall separating the orbit from the ethmoid sinus. Although the distribution of Keros classification varies among

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different populations, most studies have reported Keros type II as the predominant subtype. In a series of 1,200 patients, Babu et al. reported the prevalence of Keros type I, II, and III as 17.5%, 74.6%, and 7.9%, respectively [6]. Similarly, Almushayti et al. reported Keros type II as the most common subtype (53.2%) in a cohort of 511 patients [5]. These findings are consistent with the Keros distribution in our study and support that the distribution in both groups is in line with the literature. The absence of a difference in Keros type and absolute OFD, together with the significant differences in the asymmetry parameters described below, indicates that the anterior skull base variation associated with LPD concerns the symmetry of the skull base rather than its absolute depth. This distinction is clinically relevant: if the preoperative report is limited to the Keros type, patients with LPD would generally be placed in the same risk category as patients without LPD, and the asymmetry-related risk would remain unrecognized [7,10].

One of the principal findings of our study was the statistically significant difference in the classification of right-to-left OFD differences between the LPD and control groups ($p = 0.04$). This finding suggests that asymmetry in anterior skull base depth may be more pronounced in patients with LPD than in individuals without LPD. Since LPD was not associated with absolute OFD, this finding may reflect a more general tendency toward asymmetric development of the ethmoid complex in patients with LPD. The lamina papyracea and the lateral lamella of the cribriform plate are both components of the ethmoid bone, and a developmental variation of the ethmoid labyrinth could plausibly be expressed both as a medial orbital wall defect and as asymmetric skull base morphology.

An asymmetric configuration of the anterior skull base is recognized as an important surgical risk factor. Specifically, asymmetry in OFD may increase the risk of lateral lamella injury and subsequent CSF leakage if the surgeon applies the same anatomical landmarks to both sides without recognizing differences in skull base depth [10,13,14]. Cashman et al. emphasized that skull base asymmetry is a critical parameter during preoperative CT evaluation before FESS, as failure to recognize depth differences between the two sides may increase the risk of intraoperative complications [13]. Similarly, Salih et al. reported OF asymmetry in approximately one-quarter of patients and concluded that this finding should be carefully considered during preoperative planning and communication among surgeons [14]. Furthermore, the Thailand-Malaysia-Singapore (TMS) classification proposed by Abdullah et al. incorporates asymmetry (>3 mm difference) together with OFD, demonstrating that both parameters can be used to more accurately predict the risk of anterior skull base injury [10]. In this context, the greater right-to-left OFD differences observed in patients with LPD in our study suggest that these patients should undergo more meticulous preoperative assessment, not only with respect to the integrity of the medial orbital wall but also regarding anterior skull base symmetry.

Correlation analysis performed in the study group demonstrated a moderate positive correlation between the right-to-left OFD difference and left OFD ($r = 0.547$, $p < 0.0001$), as well as a moderate positive correlation between the right-to-left OFD difference and left Keros classification ($r = 0.401$, $p = 0.004$). These findings suggest that greater left-sided OFD is associated with increased asymmetry between the two sides. In other words, the presence of a unilaterally deep OF appears to be one of the principal determinants of anterior skull base asymmetry. Because a deeper OF is associated with a longer and thinner lateral lamella [6,7], this finding implies that, in patients with LPD and a marked interside difference, the side with the deeper OF—which may differ from the side of the dehiscence—should be explicitly specified in the CT report, as this is the side at greatest risk of skull base penetration. These findings are consistent with those reported by Naaz et al. in a series of 256 patients, in which substantial inter-side differences in Keros classification were observed within the same individual, leading the authors to recommend independent evaluation of both sides during preoperative surgical planning [15]. Similarly, Muñoz-Leija et al. demonstrated that OFD and the associated patterns of ethmoid roof asymmetry may vary considerably owing to individual anatomical variation, even when demographic factors such as sex are considered [16]. Likewise, in a cone-beam CT-based study, Mahdian and Karbasi Kheir identified cribriform plate depth asymmetry in 33.3% of cases, a prevalence that is consistent with the findings of the present study [17].

Another important finding of our study was the highly significant difference in fovea ethmoidalis asymmetry between the LPD and control groups ($p < 0.0001$). The fovea ethmoidalis is a thin bony structure that forms the roof of the ethmoid sinus and is continuous with the cribriform plate through the lateral lamella. Owing to its delicate osseous architecture and close proximity to the dura, this region represents one of the most common sites of anterior skull base CSF leakage [18,19]. Previous studies have reported that approximately 80% of iatrogenic CSF leaks occur at the level of the cribriform plate and fovea ethmoidalis [19]. The marked fovea ethmoidalis asymmetry observed in patients with LPD in our study suggests that these individuals may exhibit greater anatomical variability not only with respect to the medial orbital wall but also regarding anterior skull base morphology. In unselected populations, the prevalence of ethmoid roof height asymmetry has been reported as approximately 10% by Dessi et al. and Lebowitz et al., and as 31% by Reiß and Reiß in a series of 644 patients, with the right ethmoid roof being lower in the majority of asymmetric cases [20-22]. The significantly higher frequency of fovea ethmoidalis asymmetry in our LPD group than in the matched control group therefore suggests that this finding is not merely a reflection of normal population variability but is related to the presence of LPD. These findings raise the hypothesis that LPD may represent more than an isolated defect of the medial orbital wall and could instead be part of

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a broader spectrum of skull base-orbital interface vulnerability. Nevertheless, this hypothesis should be interpreted with caution and requires confirmation in prospective studies with larger sample sizes.

Correlation analysis performed in the study group demonstrated a moderate negative correlation between fovea ethmoidalis asymmetry and left Keros classification ($r = -0.456$, $p = 0.001$). This finding suggests that increasing left-sided Keros type, reflecting greater OFD, is associated with a lower degree of fovea ethmoidalis asymmetry. In contrast, a strong positive correlation was observed between the right and left Keros classifications ($r = 0.704$, $p < 0.0001$), indicating that Keros types generally correspond closely between the two sides. However, this overall concordance should not be interpreted as evidence of complete anatomical symmetry. These findings support the observations of Naaz et al. and Babu et al., who reported that although Keros classification is usually similar bilaterally, clinically relevant asymmetry should not be overlooked during preoperative assessment [6,15]. The negative correlation between fovea ethmoidalis asymmetry and left Keros type further suggests that ethmoid roof asymmetry is not simply a consequence of a deep OF but represents a partly independent morphological variable. This is in line with the observation of Lebowitz et al. that height asymmetry and contour asymmetry of the ethmoid roof are distinct entities [21], and with more recent classification systems, such as the TMS and Gera classifications, which incorporate parameters beyond OFD [10,23]. Clinically, this means that a shallow OF (Keros type I or II) should not be regarded as reassuring in patients with LPD when the ethmoid roof is asymmetric.

From a surgical perspective, our findings suggest that in patients with LPD, preoperative CT reports should emphasize not only the integrity of the medial orbital wall but also OFD asymmetry and fovea ethmoidalis asymmetry, as these features may provide valuable information for planning FESS. In particular, in patients with LPD and a deep, asymmetric anterior skull base configuration, surgeons should remain aware of the increased risk of orbital penetration as well as CSF leakage associated with anatomical asymmetry. Consistent with our findings, Abdullah et al. emphasized that Keros classification alone may be insufficient for predicting the risk of anterior skull base injury and recommended that skull base asymmetry and additional anatomical reference landmarks, such as the orbital floor, should be evaluated together to improve surgical risk assessment [10]. Although major complications of endoscopic sinus surgery are rare—a nationwide analysis of 62,823 procedures reported CSF leak and orbital injury rates of 0.17% and 0.07%, respectively [24]—their consequences can be severe, and their prevention depends largely on preoperative recognition of high-risk anatomy. Our findings suggest that LPD should be regarded as a marker that prompts a systematic evaluation of the anterior skull base, in line with structured preoperative checklists such as the "CLOSE" approach, in which the cribriform plate and the lamina papyracea are assessed as separate items [8]. In practical terms, when LPD is identified, we recommend that the radiology report also include the Keros type of each side, the right-to-left OFD difference, and the presence and side of fovea ethmoidalis asymmetry. By demonstrating that these two high-risk regions may coexist in the same patient, our study adds to the literature, in which they have mostly been examined separately.

To the best of our knowledge, this is one of the few studies to evaluate LPD and anterior skull base morphometric parameters together in the same patient series and in comparison with an age- and sex-matched control group. Other strengths of our study include the strict exclusion of patients with trauma, previous sinonasal or skull base surgery, sinonasal polyposis, masses, or other conditions that could secondarily affect the integrity of the lamina papyracea or skull base, which allowed LPD to be evaluated as an anatomical variation; the use of a single CT scanner with a standardized acquisition protocol; and the evaluation of all measurements on multiplanar reformatted images by an experienced head and neck radiologist using predefined criteria.

Our study also has several limitations. First, it was a single-center retrospective study with a relatively limited sample size, which reduced statistical power, particularly for subgroup analyses according to dehiscence side, grade, and content; in addition, bilateral LPD was observed in only one patient. Second, all measurements were performed by a single radiologist; therefore, inter- and intra-observer agreement could not be assessed. Third, the 2-mm slice thickness may have led to underestimation of small dehiscences and minor interside differences owing to partial volume effects. Fourth, other parameters related to the risk of skull base injury, such as the length and angle of the lateral lamella of the cribriform plate (Gera classification) and the course of the anterior ethmoidal artery, were not evaluated [23]. Finally, clinical and surgical outcomes were not evaluated, and the effect of the radiological findings on actual surgical risk could not be directly demonstrated; prospective studies with larger sample sizes that include surgical outcomes are needed in this regard.

Conclusion

In conclusion, in this study, it was determined that right-left OFD difference and foveal ethmoidalis asymmetry were significantly more common in patients with LPD compared to the control group, whereas Keros classification and OFD values did not differ between the two groups. These findings suggest that LPD is not an isolated finding involving only orbital wall integrity but may also be associated with anterior skull base asymmetry. In patients with LPD detected on preoperative paranasal sinus CT evaluation, the radiologist's report of not only the presence, side, and degree of dehisence, but also OF asymmetry and foveal ethmoidalis asymmetry may provide valuable additional information to the surgeon planning FESS in terms of preventing both orbital and skull base complications.

Ethical Approval
Pamukkale University Faculty of Medicine Ethics Committee was approved for the study (Number: E-60116787-020-906559; Date: 21.07.2026).

Patient Consent
Informed consent was not obtained from the patients due to the retrospective nature of the study and the evaluation of previously acquired CT images.

Conflict of Interest
The authors confirm the absence of any conflicts associated with this work.

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